REMARKS

In the last Office Action, the Examiner acknowledged applicant's claim for foreign priority but pointed out that applicant has not filed a certified copy of the Japanese application. Applicant respectfully notes that a certified copy thereof will be filed at the time of payment of the issue fee herein.

Claims 1-4 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,118,122 to Koyama et al. ("Koyama"). With respect to claim 1, the Examiner stated that Koyama discloses a focused charged particle beam device having a charged particle source 9, a focusing lens system 2, a blanking electrode 3, a deflection electrode 8, a sample stage 15, a gas gun 13, and a sample stage drive means comprising a mechanism capable of movement in three dimensions and capable of tilting in two axial directions (citing col. 3, lines 3-8). With respect to claim 2, the Examiner stated that Koyama discloses tilting the sample in two axial directions. With respect to claim 3, the Examiner stated that Koyama discloses a means for data storage and controlling tilt angle 19. With respect to claim 4, the Examiner stated that Koyama discloses a gas gun for spraying a gas for assist etching of a mask material, or deposition gas. With respect to all of claims 1-4, the Examiner pointed out that the recitation that

an element is "capable of" performing a function is not a positive limitation but only requires the ability to so perform (citing In re Hutchinson, 69 USPQ 138). Thus, the Examiner did not give patentable weight to recitations in claims 1-4 reciting that an element is "capable of" performing a given function.

By the present response, the specification has been suitably revised in editorial respects to improve the wording and correct informalities. Claims 1-4 have been amended to more particularly point out and distinctly claim the novel features of the present invention. To obtain a broader and more comprehensive scope of coverage, new claims 5-20 have been added. In addition, a new abstract which more clearly reflects the invention to which the amended and new claims are directed has been substituted for the original abstract.

Submitted herewith is a replacement sheet for Fig. 1B incorporating revisions thereto. As can be seen, Fig. 1B has been revised to add a computer 24 and X and Y direction actuators 26 and 28.

Applicant respectfully submits that claims 1-20 patentably distinguish over the prior art of record.

The present invention relates to technology for fine processing of a sample such as a stencil mask of the type used in Electron beam Projection Lithography (EPL). Until

recently, optical lithography technology has been a mainstay in semiconductor processing applications. However, fine patterning of samples using light exposure has gradually reached its limit. Therefore technology for irradiating electron beams and extremely short ultraviolet rays instead of light has been explored. However, a problem has arisen when using a focused charged particle beam for fine processing applications such as the correction of stencil mask used for EPL.

In a fine processing device using a focused charged particle beam, such as an focused ion beam (FIB) device, the strength of the focused charged particle beam is not uniform throughout the cross section of the beam. Since there is usually a normal power distribution, the edges of the beam are significantly attenuated. Thus, even if beam incidence is vertical, a processed cross section is not vertical. If an opaque defect 7 such as that shown on the left side of Fig. 3 is subjected to sputtering using a focused ion beam 5, the processed surface takes on an undesirable tapered shape.

The dimensions of devices such as electron beam exposure masks are becoming increasingly fine, and correction accuracy must also be further improved. As a correction error, the tapered shape of a cross section due to this error can not be ignored. For example, in the case of an Si

membrane 2μm thick, with an inclination angle of 2 degrees, the dimensional error at the rear surface of a mask would be about 70nm. With EPL, at the time of exposure there is typically projection to 1/4 of the size. Thus, in forming a 50nm pattern, the mask pattern becomes 200nm or less. Under conditions such as these, a dimensional error due to inclination of a pattern having a penetrating structure is a significant problem.

FIB processing perpendicular to a cross section has been important. For example, at the time of processing a sample for extremely thin plate applications using an FIB device, the sample is tilted a few degrees and etched, and a TEM observation surface is then processed perpendicularly. Accordingly, although it is necessary to make the process cross section of the mask perpendicular, even if an electron beam exposure mask is inclined, as in TEM sample processing, and the process cross section made perpendicular, the pattern of a mask having a penetrating structure does not have a process surface where the two sides are parallel surfaces, and all surfaces through 360° must be taken. To do this, it is necessary to tilt the sample stage corresponding to all angles. A sample stage of a conventional FIB fine processing device has a 5 axis stage (XYZRT) (wherein R is rotation and T is tilt). However, the direction of tilt of the sample is

limited to one direction in the conventional apparatus. In the case of slice processing, the capability of tilt in one direction is not a problem. However, in the case of processing used to form patterns having various directions, such as an electron beam exposure mask, tilt capability in only one direction makes it necessary to frequently rotate and move the sample during processing. In particular, many rotation functions are needed, which means that tilting the mask and carrying out processing to form a perpendicular surface is difficult.

The present invention overcomes this problem by providing a focused charged particle beam device capable of enabling accurate perpendicular processing of pattern surfaces in all directions such as when performing correction processing for pattern defects of a penetrating structure in an electron beam exposure mask.

As recited by amended independent claim 1, the inventive focused charged particle beam device comprises a charged particle source, a focusing lens system for focusing a charged particle beam emitted from the charged particle source, a blanking electrode for turning the charged particle beam ON or OFF, a deflection electrode for deflecting the focused charged particle beam to scan the charged particle beam on a sample, a sample stage having drive means comprising

a movement mechanism for movement along three axes and a tilting mechanism mounted below the movement mechanism for tilting movement about two of the three axes, a point at which the two axes of the tilting mechanism cross being aligned with an optical axis of the focusing lens system, and a gas gun for spraying gas for deposition or to assist etching.

Accordingly, the sample stage drive means comprises a mechanism capable of tilting about two axes (X and Y) and a mechanism capable of movement along three axes (X, Y and Z) to enable tilting in all directions. The present invention provides a focused charged particle beam device capable of accurate perpendicular processing of pattern surfaces in all directions without any difficulty, such as when performing correction processing for pattern defects of a penetrating structure in an electron beam exposure mask.

An embodiment of the present invention is shown in Figs. 1A and 1B. Orthogonal X and Y axes are set so as to align with the sample surface, and the point at which they cross is set to align with the optical axis of an optical system of the device. This is done in order to ensure that there is no positional slip of the sample due to tilt operations about the axis. The tilt mechanism is arranged below the movement mechanism of the sample stage drive mechanism. By this structure, it is made possible to tilt the

sample surface in all directions around the optical system, and at the same time there is no deviation of the crossing point, which is a central part of the sample, from the beam irradiation position (on the axis of the lens optical system) even if the sample is tilted.

Notably, the processing position of the sample surface is not always the center of the sample. However, by having an XY drive mechanism mounted on the tilt mechanism, an X,Y sliding surface will be tilted at the same angle so that regardless of where the processing location is, if that X,Y coordinate position is moved to it will be possible to hold the location at the same beam irradiation position.

As further illustrated in Fig. 1B, the sample stage in the preferred embodiment comprises an inclining stage which is capable of movement at any angle through 360° with two orthogonal axes as a center, and a high precision 3-axis stage (XYZ) is mounted on the inclining stage. The double tilt mechanism has a stage side hemispherical protuberance fitted into a hemispherical indentation formed in a fixed body section, to form a hemispherical slide mechanism 10, and also comprises a tilt drive mechanism for tilting about two orthogonal axes.

Since the focused charged particle beam device of the present invention has a mechanism capable of movement

along three axes (X,Y and Z) and has mounted therebelow a mechanism capable of tilting about two of the three axes (X and Y) and has a mechanism capable of setting a sample surface in a tilt angle range from perpendicular to a few degrees with respect to the focused charged particle beam, it is possible to perform fine processing, such as the correction of a defect in an electron beam exposure mask, and to do so by making a mask process surface perpendicular.

Koyama fails to disclose or suggest the claimed invention recited by amended independent claim 1. Instead, Koyama discloses a sample stage 12 that effects predetermined XYZ direction movement of a sample 11, rotation of the sample 11 about a normal to the XY plane as an axis, and tilting/ rotation on the two axes XY. Koyama does not indicate that the tilting is performed about the X and Y axes, but merely that the rotation/tilting is performed on the XY axes. This is the same as the conventional structure described above. Fine correction processing using the Koyama FIB device would be carried out by tilting the sample in one direction, as described above, and achieving movement in multiple directions by use of the rotating function of the sample stage 12. By providing 5 axis capability, namely movement of the sample stage in three dimensions XYZ, rotation R and tilt T, a desired tilt angle can be theoretically achieved in the Koyama

device using both the rotation and tilt mechanisms. By using the rotation mechanism, it is possible to perpendicularly process a slice in all directions for a pattern of a penetrating structure for an electron beam exposure mask. However, if this is practically implemented, processing locations that are not on the rotational axis suffer from positional deviation due to the rotational drive, and time and effort are wasted in operating the drive mechanism to correct this positional error. Taking into account the fact that this is unrealistic in practical terms, the present invention has been conceived to arrange a two axis tilt (double tilt) mechanism at the lowest position in a sample stage drive mechanism, and to have a mechanism capable of realizing tilt in all directions with respect to an optical axis in a state where it is difficult for positional error to arise.

In the absence of the foregoing disclosure recited in amended independent claim 1, anticipation cannot be found. See, e.g., W.L. Gore & Associates v. Garlock, Inc., 220 USPQ 303, 313 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) ("Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration"); Continental Can Co. USA v. Monsanto Co., 20 USPQ2d 1746, 1748 (Fed. Cir. 1991)("When more than one reference is required to establish unpatentability of the claimed invention

anticipation under §102 can not be found"); Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co., 221 USPQ 481, 485 (Fed. Cir. 1984)("Anticipation requires the presence in a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim") (emphasis added).

Stated otherwise, there must be no difference between the claimed invention and the reference disclosure, as viewed by a person of ordinary skill in the field of the invention. This standard is clearly not satisfied by Koyama for the reasons stated above. Furthermore, Koyama does not suggest the claimed subject matter and, therefore, would not have motivated one skilled in the art to modify Koyama to arrive at the claimed invention.

More specifically, Koyama fails to disclose or suggest a tilting mechanism mounted below a movement mechanism for tilting movement of a sample stage about two axes as recited by amended independent claim 1. Nor does Koyama disclose that a point at which the two axes of the tilting mechanism cross is aligned with an optical axis of the focusing lens system as further recited by amended independent claim 1.

Newly added independent claim 6 also recites a tilting mechanism mounted below a movement mechanism for

tilting the sample stage about two axes, which is neither disclosed nor suggested by Koyama.

Newly added independent claim 12 also recites a tilting mechanism for tilting movement of the sample stage about two axes, and further recites that the device does not rotate the sample stage in a plane. Koyama clearly discloses a rotating mechanism for rotating a sample stage in the XY plane. Thus, Koyama does not anticipate or render obvious the subject matter of claim 12.

Claims 2-5, 7-11 and 13-20 depend on and contain all of the limitations of amended independent claims 1, 6 and 12, respectively and, therefore, distinguish from the reference at least in the same manner as the base claims.

In view of the foregoing, applicant respectfully requests withdrawal of the rejection of claims 1-4 under 35 U.S.C. §102(b) as being anticipated by Koyama.

In view of the foregoing amendments and discussion, the application is believed to be in allowable form. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

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Name

_____
Signature

May 31, 2005
Date

IN THE DRAWINGS:

Submitted herewith is a replacement sheet for Fig. 1B which has been revised to add a computer 24 and X and Y direction actuators 26 and 28.